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ABSTRACT

Objectives. This study examined whether socioeconomic status has a differential effect on the survival of adults diagnosed with cancer in Canada and the United States.

Methods. The Ontario Cancer Registry and the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program provided a total of 58 202 and 76 055 population-based primary malignant cancer cases for Toronto, Ontario, and Detroit, Mich, respectively. Socioeconomic data for each person's residence at time of diagnosis were taken from population censuses.

Results. In the US cohort, there was a significant association between socioeconomic status and survival for 12 of the 15 most common cancer sites; in the Canadian cohort, there was no such association for 12 of the 15 sites. Among residents of low-income areas, persons in Toronto experienced a survival advantage for 13 of 15 cancer sites at 1- and 5-year follow-up. No such between-country differentials were observed in the middle- or high-income groups.

Conclusions. The consistent pattern of a survival advantage in Canada observed across various cancer sites and follow-up periods suggests that Canada's more equitable access to preventive and therapeutic health care services is responsible for the difference. (*Am J Public Health.* 1997;87:1156–1163)

Introduction

Seven of eight recent United States studies on cancer survival found a significant survival disadvantage with low socioeconomic status (SES).[1–8] Cumulative survival rates among patients of relatively high SES were found to be approximately 50% greater than those of their lower-status counterparts (mean odds ratio [OR] = 1.50, crudely averaged across studies and cancer sites). A similar association between SES and cancer survival, though of attenuated magnitude (mean OR = 1.20), has also been observed in recent studies carried out in continental European[9–15] and Nordic[16–20] countries, as well as Australia.[21] This association has been consistently observed for many of the most common cancer sites not only across countries, but also across different measures of SES (individual and ecological; education-, occupation-, housing-, and income-based) and study designs (population- and hospital-based; observational and analytic). Also, recent US studies on race and cancer survival have provided further, albeit more indirect, evidence for such an association.[22–31] Cumulative survival among Blacks was found to be approximately 40% lower than that of Whites (mean OR = 1.40); however, the summary odds ratio diminished to 1.06 after adjustment for socioeconomic factors, a point-estimate the combined probability of which did not even reach a minimally significant $P < .05$.[32]

This body of evidence seems to implicate systemic environmental factors, rather than individual ones, as explanations for cancer survival differentials by SES. For example, the US studies of cancer survival by race with socioeconomic adjustment imply that most (1 − .06/.40 = 85%) of the between-race differential is probably accounted for by prognostic (size of tumor or stage of disease at diagnosis; delay until medical consultation, type of insurance, relationship with primary care physician, cancer screening experience) and treatment (timeliness, type, and intensity) factors. Biological factors (degrees of tumor differentiation, histology, hormone receptor status) accounted for little or none of the difference. The above between-country meta-analytic comparison is also consistent with the systemic environmental inference. Health care system differences, such as the greater representation of universal single-payer systems in the Nordic and other European countries, may parsimoniously account for the greatly diminished associations between SES and cancer survival found in these countries as compared with the United States. It ought to be recalled, though, that this inference is based on review-generated data; none of the reviewed studies actually compared the survival experience of two or more

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Editor's Note. See related annotation by Schatzkin on p 1095 in this issue.

countries in any controlled manner. The present study does so.

We are aware of only one previous study—a US General Accounting Office (GAO) study—that has compared the cancer survival experience of a US sample and a sample from another country.[33] It compared Canada and the United States on lung, breast, and colon cancer and Hodgkin's disease survival. Five-year survival rate ratios indicative of a small advantage were observed for lung (1.05, Canada advantage) and breast (1.04, US advantage) cancer, while colon cancer and Hodgkin's disease comparisons were statistically nonsignificant. Such cancer survival similarity between these two developed countries—arguably very similar in many sociodemographic respects, but dissimilar in the manner in which health care resources are distributed—is counter to the present study's hypothesis. In light of the consistent literature on SES and cancer survival, the GAO study findings seem counterintuitive; one would expect significant benefits to be observed among Canadians, who enjoy universal access to health care. The GAO study did not include any measure of SES, and so could not observe any modification of between-country survival differences by SES. We hypothesized such an interaction, specifically, that relatively poor Canadians would enjoy advantaged cancer survival over their similarly poor US counterparts.

Methods

Cancer cases arose from the populations of greater metropolitan Toronto, Ontario (3.5 million in 1991; Toronto, York, and Peel regions), and Detroit, Mich (3.9 million in 1990; Wayne, Oakland, and Macomb counties).[34,35] Both cities are on or very near to the Canadian–US border, only 200 miles apart. They are also both located on the Great Lakes (Toronto on Lake Ontario and Detroit on Lakes Erie and Huron via the Detroit River) and are exposed to the same general prevailing wind-driven weather patterns.

The data sources were the Ontario Cancer Registry (Toronto data) and the National Cancer Institute's Surveillance Epidemiology and End Results (SEER) program (Detroit data). Definitions of the study cohorts were constrained by the following: 1986 was the first year in which the Ontario Cancer Registry coded most cases by residence (mandated hospital reporting was initiated), and cohort terminations or dates of last follow-up for

TABLE 1—Association of Socioeconomic Status with Cancer Survival: Toronto, Ontario, 1993

Cancer Site (ICD-9 Code) and Income Group	1-Year Survival				5-Year Survival			
	n[a]	SR	SRR[b]	(95% CI)[c]	n[d]	SR	SRR[b]	(95% CI)[c]
Women								
Lung–bronchus (162)								
High	834	.391	1.00	. . .	280	.184	1.00	. . .
Middle	1329	.396	1.01	(0.93, 1.10)	551	.176	0.96	(0.76, 1.21)
Low	1427	.407	1.04	(0.94, 1.15)	597	.150	0.82	(0.61, 1.10)
Breast (174)								
High	3122	.937	1.00	. . .	1164	.709	1.00	. . .
Middle	3936	.935	1.00	(0.99, 1.01)	1509	.707	1.00	(0.94, 1.06)
Low	3687	.928	0.99	(0.98, 1.00)	1526	.696	0.98	(0.93, 1.04)
Colon (153)								
High	866	.694	1.00	. . .	361	.375	1.00	. . .
Middle	1378	.754	1.09	(1.03, 1.15)	576	.506	1.35	(1.16, 1.57)
Low	1243	.738	1.06	(1.01, 1.12)	570	.477	1.33	(1.14, 1.55)
Bladder (188)								
High	209	.859	1.00	. . .	105	.714	1.00	. . .
Middle	287	.800	0.93	(0.86, 1.01)	138	.649	0.91	(0.76, 1.09)
Low	325	.799	0.93	(0.86, 1.01)	157	.594	0.83	(0.69, 0.99)
Rectum (154)								
High	303	.796	1.00	. . .	116	.410	1.00	. . .
Middle	474	.779	0.98	(0.91, 1.05)	193	.422	1.03	(0.58, 1.84)
Low	443	.808	1.02	(0.89, 1.17)	198	.432	1.05	(0.81, 1.37)
Non-Hodgkin's lymphoma (202)								
High	324	.679	1.00	. . .	133	.385	1.00	. . .
Middle	441	.691	1.02	(0.95, 1.09)	170	.470	1.22	(0.94, 1.58)
Low	484	.663	0.98	(0.85, 1.13)	193	.416	1.08	(0.82, 1.42)
Corpus uterus (182)								
High	549	.929	1.00	. . .	214	.787	1.00	. . .
Middle	759	.927	1.00	(0.96, 1.04)	327	.813	1.03	(0.96, 1.11)
Low	697	.932	1.00	(0.97, 1.03)	311	.780	0.99	(0.81, 1.21)
Stomach (151)								
High	178	.442	1.00	. . .	68	.214	1.00	. . .
Middle	319	.467	1.06	(0.85, 1.33)	136	.219	1.02	(0.69, 1.50)
Low	396	.435	0.98	(0.82, 1.17)	164	.190	0.89	(0.58, 1.36)
Oral (141–149)								
High	135	.871	1.00	. . .	50	.498	1.00	. . .
Middle	218	.841	0.97	(0.91, 1.04)	95	.509	1.02	(0.58, 1.77)
Low	254	.807	0.93	(0.85, 1.01)	115	.560	1.12	(0.81, 1.55)
Pancreas (157)								
High	234	.202	1.00	. . .	93	.027	1.00	. . .
Middle	337	.198	0.98	(0.52, 1.83)	133	.057	2.11	(0.45, 9.90)
Low	356	.212	1.05	(0.75, 1.47)	147	.049	1.81	(0.26, 12.60)
Kidney (189)								
High	191	.801	1.00	. . .	70	.587	1.00	. . .
Middle	281	.748	0.93	(0.84, 1.03)	129	.611	1.04	(0.84, 1.29)
Low	298	.756	0.94	(0.85, 1.04)	121	.502	0.86	(0.65, 1.13)
Ovary (183)								
High	448	.689	1.00	. . .	165	.371	1.00	. . .
Middle	637	.717	1.04	(0.96, 1.12)	232	.417	1.12	(0.89, 1.40)
Low	612	.696	1.01	(0.93, 1.10)	259	.406	1.09	(0.87, 1.37)
Cervix uterus (180)[e]								
High	258	.882	1.00	. . .	93	.630	1.00	. . .
Middle	364	.869	0.99	(0.96, 1.02)	158	.638	1.01	(0.83, 1.23)
Low	492	.892	1.01	(0.95, 1.07)	218	.647	1.03	(0.77, 1.38)
Brain–CNS (191–192)								
High	174	.434	1.00	. . .	68	.266	1.00	. . .
Middle	246	.407	0.94	(0.77, 1.14)	114	.261	0.98	(0.28, 3.43)
Low	227	.478	1.10	(0.88, 1.38)	91	.301	1.13	(0.64, 1.99)

(Continued)

TABLE 1—*Continued*

Cancer Site (ICD-9 Code) and Income Group	1-Year Survival n[a]	SR	SRR[b]	(95% CI)[c]	5-Year Survival n[d]	SR	SRR[b]	(95% CI)[c]
Men								
Lung-bronchus (162)								
High	1563	.368	1.00	...	622	.111	1.00	...
Middle	2402	.359	0.98	(0.91, 1.05)	1029	.142	1.28	(0.98, 1.67)
Low	2835	.354	0.96	(0.88, 1.05)	1251	.132	1.19	(0.91, 1.55)
Prostate (185)								
High	2044	.903	1.00	...	636	.585	1.00	...
Middle	2713	.906	1.00	(0.98, 1.02)	897	.559	0.96	(0.89, 1.04)
Low	2410	.892	0.99	(0.97, 1.01)	857	.546	0.93	(0.85, 1.02)
Colon (153)								
High	929	.771	1.00	...	362	.485	1.00	...
Middle	1294	.761	0.99	(0.95, 1.03)	532	.450	0.93	(0.82, 1.06)
Low	1234	.750	0.97	(0.92, 1.02)	547	.471	0.97	(0.85, 1.11)
Bladder (188)								
High	638	.872	1.00	...	308	.643	1.00	...
Middle	872	.880	1.01	(0.97, 1.05)	428	.659	1.02	(0.94, 1.11)
Low	864	.885	1.01	(0.99, 1.03)	414	.598	0.93	(0.83, 1.05)
Rectum (154)								
High	407	.798	1.00	...	153	.472	1.00	...
Middle	594	.778	0.97	(0.90, 1.05)	226	.353	0.75	(0.58, 0.96)
Low	614	.769	0.96	(0.89, 1.03)	267	.423	0.90	(0.72, 1.12)
Non-Hodgkin's lymphoma (202)								
High	390	.690	1.00	...	139	.438	1.00	...
Middle	499	.659	0.96	(0.88, 1.04)	208	.430	0.98	(0.80, 1.19)
Low	611	.572	0.83	(0.75, 0.91)	210	.363	0.83	(0.64, 1.07)
Stomach (151)								
High	335	.426	1.00	...	119	.150	1.00	...
Middle	462	.435	1.02	(0.86, 1.21)	167	.157	1.05	(0.40, 2.73)
Low	634	.440	1.03	(0.89, 1.19)	281	.195	1.30	(1.10, 1.54)
Oral (141–149)								
High	226	.805	1.00	...	85	.502	1.00	...
Middle	408	.798	0.99	(0.88, 1.11)	158	.514	1.02	(0.69, 1.50)
Low	528	.740	0.92	(0.84, 1.00)	236	.452	0.90	(0.70, 1.15)
Pancreas (157)								
High	212	.175	1.00	...	86	.035	1.00	...
Middle	348	.184	1.05	(0.77, 1.44)	136	.046	1.31	(0.28, 6.02)
Low	359	.180	1.03	(0.77, 1.38)	165	.078	2.23	(0.70, 7.08)
Kidney (189)								
High	336	.732	1.00	...	127	.537	1.00	...
Middle	438	.790	1.08	(1.00, 1.17)	173	.567	1.06	(0.86, 1.31)
Low	467	.728	0.99	(0.86, 1.14)	183	.522	0.97	(0.69, 1.33)
Brain–CNS (191–192)								
High	210	.472	1.00	...	88	.211	1.00	...
Middle	285	.416	0.88	(0.71, 1.09)	128	.181	0.86	(0.55, 1.34)
Low	269	.416	0.88	(0.71, 1.09)	111	.262	1.24	(0.70, 2.20)

Note. ICD-9 = *International Classification of Diseases*, 9th revision; n = number of cumulative incident cancer cases; SR = cumulative survival rate; SRR = survival rate ratio; CI = confidence interval; CNS = central nervous system.
[a]Cases diagnosed between 1986 and 1992.
[b]A survival rate ratio of 1.00 is the baseline.
[c]Confidence intervals are based on the Mantel-Haenszel chi-squared test.
[d]Cases diagnosed between 1986 and 1988.
[e]Invasive.

the Toronto and Detroit cases were December 31, 1993 and 1991, respectively.[36] So the Toronto cohort for 1-year survival analysis was based on cumulative incident cases diagnosed from 1986 through 1992, and that for the 5-year survival analysis was based on cases diagnosed from 1986 through 1988; both were followed until December 1993. The Detroit cohort was initiated in 1984 and followed until December of 1991. All primary, malignant cancers in the 15 most common sites that occurred in adults (25 years of age or older) were included in the analysis: 58 202 cases in Toronto and 76 055 in Detroit. The Ontario Cancer Registry has been estimated to ascertain more than 95% of the cancers that arise in the province, which compares favorably with the SEER-based Detroit registration rate.[37] This study's specific metropolitan data sets were also found to be nearly identical on other data quality indicators: in the Toronto data set, 89.2% of the cancers were microscopically confirmed and 1.6% were enumerated on the basis of death certificates only; for the Detroit data set these figures were 90.6% and 1.4%, respectively.

As is the case with nearly all cancer registries, neither the Ontario nor the SEER registry codes any socioeconomic variables. Cancer cases were thus joined by means of census tracts to socioeconomic data collected by the 1991 and 1990 population censuses in Canada and the United States, respectively. Such geographic coding was based on each person's residence at the time of diagnosis; these data were coded as postal codes (converted to census tracts) in the Ontario data set and as census tracts in the SEER data set.[38,39] The overall residential coding rates for the two data sets were found to be roughly comparable (Toronto = 94% and Detroit = 98%).

Statistics Canada and the US Bureau of the Census use conceptually similar indices of economic impoverishment—"low income" in Canada and "poverty" threshold in the United States—which facilitated this study's ecological between-country comparison. Both are based on annual household income from all sources, adjusted for household size and tied to the consumer price index. The Canadian low-income cutoff is a more liberal criterion, though, approximately equal to 200% of the US poverty threshold. For example, in 1991 the Canadian low-income threshold for a three-person household was $24 400 (Canadian dollars), while in 1990 the US poverty threshold for the same size household, adjusted for the US dollar exchange rate, was $11 700.[40] These criteria were used to divide the two cohorts into low, middle, and high socioeconomic tertiles. The analytic goal for the use of such census-based socioeconomic measures was simply the aggregation of cancer cases into *relative* tertiles, that is, low-, middle-, and high-income areas within countries. The

1990 Toronto–Detroit comparison on income status by tertile, in US dollars, was as follows: high income (240 census tracts, median income of $56 600, vs 354 tracts, $51 500), middle income (244, $43 300, vs 355, $35 700), and low income (244, $30 400, vs 356, $17 800). The median Toronto census tract had 4843 residents, while 3661 people lived in the average Detroit tract.

Cumulative survival rates were corrected for competing causes of death by excluding such outcome events. Only deaths due to cancer were defined as valid outcomes; deaths from other causes were considered censored events.[15,19] In fact, the results of such censored analyses differed little in most cases from analyses performed with the uncorrected observed survival rates, so the corrected findings are reported alone in this paper. Survival rates were directly age-adjusted, using this study's combined Toronto–Detroit population of cases by each specific cancer site across the following age categories: 25 through 44, 45 through 54, 55 through 64, 65 through 74, 75 years of age or older. For within-country comparisons, the survival rate ratio (SRR) was the ratio of low- to high-income tertile survival rates; the survival rate ratio indicates worse survival for the low-income group if it is less than 1.00. Cancer survival comparisons of Canadian and US residents of low-income areas were then accomplished so that the survival rate ratio was greater than 1.00 if Toronto residents were advantaged and less than 1.00 if Detroiters were. Confidence intervals (95%) around survival rate ratios were based on the Mantel-Haenszel chi-squared test.[41,42]

Results

Within-Country Comparisons

In the Toronto metropolitan area, no association was observed between SES—low- vs high-income areas—and 1- or 5-year cancer survival for 12 of the 15 cancer sites studied (Table 1). The only exceptions to this remarkably consistent lack of association were for colon cancer in women and non-Hodgkin's lymphoma and oral cancer in men at 1-year follow-up, and colon and bladder cancer in women and stomach cancer in men at 5 years. Unexpectedly, an association in the opposite direction—residents of lower-income areas survived longer—was observed among women with colon cancer, and this is probably not a spurious finding,

TABLE 2—Association of Socioeconomic Status with Cancer Survival: Detroit, Mich, 1991

Cancer Site (ICD-9 Code) and Income Group	1-Year Survival				5-Year Survival			
	n	SR	SRR[a]	(95% CI)[b]	n	SR	SRR[a]	(95% CI)[b]
Women								
Lung–bronchus (162)								
High	1528	.438	1.00	...	336	.157	1.00	...
Middle	1706	.396	0.90	(0.82, 0.98)	344	.104	0.66	(0.42, 1.03)
Low	2250	.341	0.78	(0.71, 0.85)	892	.095	0.61	(0.43, 0.86)
Breast (174)								
High	5071	.917	1.00	...	1101	.671	1.00	...
Middle	4470	.914	1.00	(0.99, 1.01)	1036	.632	0.94	(0.88, 1.01)
Low	4845	.876	0.95	(0.93, 0.97)	1850	.536	0.80	(0.75, 0.85)
Colon (153)								
High	1164	.742	1.00	...	299	.439	1.00	...
Middle	1296	.715	0.96	(0.91, 1.01)	321	.460	1.05	(0.86, 1.28)
Low	1859	.699	0.94	(0.89, 0.99)	801	.360	0.82	(0.69, 0.98)
Bladder (188)								
High	352	.800	1.00	...	86	.616	1.00	...
Middle	372	.788	0.98	(0.88, 1.09)	97	.535	0.87	(0.67, 1.14)
Low	385	.674	0.84	(0.75, 0.93)	171	.408	0.66	(0.50, 0.87)
Rectum (154)								
High	466	.824	1.00	...	117	.498	1.00	...
Middle	497	.761	0.92	(0.85, 0.99)	144	.419	0.84	(0.62, 1.13)
Low	616	.763	0.89	(0.80, 0.99)	244	.398	0.80	(0.61, 1.05)
Non-Hodgkin's lymphoma (202)								
High	489	.666	1.00	...	103	.447	1.00	...
Middle	468	.661	0.99	(0.86, 1.14)	111	.343	0.77	(0.53, 1.12)
Low	441	.620	0.93	(0.84, 1.03)	170	.327	0.73	(0.54, 0.98)
Corpus uterus (182)								
High	996	.890	1.00	...	236	.700	1.00	...
Middle	927	.880	0.99	(0.96, 1.02)	241	.590	0.84	(0.72, 0.98)
Low	899	.793	0.89	(0.85, 0.92)	397	.583	0.83	(0.72, 0.95)
Stomach (151)								
High	174	.376	1.00	...	43	.114	1.00	...
Middle	237	.410	1.09	(0.80, 1.48)	62	.135	1.18	(0.44, 3.14)
Low	388	.427	1.14	(0.87, 1.49)	169	.116	1.02	(0.82, 1.28)
Oral (141–149)								
High	201	.744	1.00	...	52	.405	1.00	...
Middle	208	.780	1.05	(0.93, 1.18)	56	.520	1.28	(0.82, 2.01)
Low	372	.697	0.94	(0.84, 1.05)	170	.400	0.99	(0.53, 1.85)
Pancreas (157)								
High	340	.156	1.00	...	103	.055	1.00	...
Middle	343	.183	1.17	(0.85, 1.62)	99	.033	0.60	(0.13, 2.81)
Low	578	.174	1.12	(0.82, 1.53)	250	.027	0.49	(0.16, 1.55)
Kidney (189)								
High	243	.695	1.00	...	67	.423	1.00	...
Middle	249	.717	1.03	(0.91, 1.16)	49	.556	1.31	(0.86, 1.99)
Low	309	.636	0.91	(0.80, 1.04)	124	.360	0.85	(0.59, 1.24)
Ovary (183)								
High	622	.692	1.00	...	146	.317	1.00	...
Middle	587	.669	0.97	(0.90, 1.04)	132	.271	0.85	(0.52, 1.40)
Low	611	.624	0.90	(0.82, 0.98)	221	.294	0.93	(0.63, 1.38)
Cervix uterus (180)[c]								
High	243	.849	1.00	...	60	.624	1.00	...
Middle	325	.823	0.97	(0.89, 1.05)	93	.489	0.78	(0.57, 1.07)
Low	633	.763	0.87	(0.78, 0.97)	252	.437	0.70	(0.53, 0.92)
Brain–CNS (191–192)								
High	202	.366	1.00	...	64	.147	1.00	...
Middle	187	.339	0.93	(0.72, 1.20)	50	.088	0.60	(0.18, 2.05)
Low	147	.282	0.77	(0.54, 1.10)	59	.122	0.83	(0.14, 2.07)

(*Continued*)

TABLE 2—*Continued*

Cancer Site (ICD-9 Code) and Income Group	1-Year Survival				5-Year Survival			
	n	SR	SRR[a]	(95% CI)[b]	n	SR	SRR[a]	(95% CI)[b]
Men								
Lung–bronchus (162)								
High	2426	.364	1.00	...	674	.114	1.00	...
Middle	2981	.339	0.93	(0.86, 1.01)	767	.088	0.77	(0.55, 1.08)
Low	4729	.297	0.82	(0.76, 0.88)	2049	.067	0.59	(0.45, 0.78)
Prostate (185)								
High	3386	.885	1.00	...	615	.540	1.00	...
Middle	3111	.844	0.95	(0.93, 0.97)	571	.457	0.85	(0.75, 0.96)
Low	4487	.814	0.92	(0.90, 0.94)	1723	.450	0.83	(0.75, 0.92)
Colon (153)								
High	1291	.751	1.00	...	310	.437	1.00	...
Middle	1207	.716	0.95	(0.90, 1.00)	285	.392	0.90	(0.73, 1.10)
Low	1700	.675	0.90	(0.86, 0.94)	647	.341	0.78	(0.65, 0.94)
Bladder (188)								
High	1099	.862	1.00	...	245	.592	1.00	...
Middle	964	.861	1.00	(0.98, 1.02)	232	.540	0.91	(0.76, 1.09)
Low	844	.777	0.90	(0.86, 0.94)	352	.466	0.79	(0.67, 0.94)
Rectum (154)								
High	656	.837	1.00	...	193	.433	1.00	...
Middle	626	.777	0.93	(0.88, 0.98)	156	.397	0.92	(0.72, 1.17)
Low	694	.738	0.88	(0.83, 0.93)	296	.375	0.87	(0.69, 1.09)
Non-Hodgkin's lymphoma (202)								
High	544	.672	1.00	...	125	.390	1.00	...
Middle	491	.662	0.99	(0.92, 1.07)	102	.326	0.84	(0.60, 1.17)
Low	475	.598	0.89	(0.80, 0.99)	190	.334	0.86	(0.65, 1.15)
Stomach (151)								
High	316	.401	1.00	...	93	.145	1.00	...
Middle	315	.398	0.99	(0.69, 1.42)	73	.128	0.88	(0.25, 3.08)
Low	659	.345	0.86	(0.71, 1.05)	249	.113	0.80	(0.39, 1.64)
Oral (141–149)								
High	405	.781	1.00	...	103	.404	1.00	...
Middle	493	.731	0.94	(0.87, 1.01)	128	.292	0.72	(0.49, 1.06)
Low	930	.611	0.78	(0.71, 0.85)	404	.248	0.61	(0.44, 0.85)
Pancreas (157)								
High	331	.146	1.00	...	81	.027	1.00	...
Middle	297	.143	0.98	(0.66, 1.46)	97	.011	0.41	(0.03, 4.98)
Low	558	.129	0.88	(0.60, 1.28)	251	.023	0.85	(0.25, 2.83)
Kidney (189)								
High	365	.742	1.00	...	92	.499	1.00	...
Middle	364	.647	0.87	(0.78, 0.97)	100	.376	0.75	(0:51, 1.11)
Low	420	.630	0.85	(0.77, 0.94)	171	.339	0.68	(0.48, 0.95)
Brain–CNS (191–192)								
High	243	.382	1.00	...	61	.124	1.00	...
Middle	192	.333	0.87	(0.66, 1.15)	50	.127	1.02	(0.55, 1.88)
Low	161	.384	1.01	(0.65, 1.56)	59	.167	1.35	(0.55, 3.33)

Note. ICD-9 = *International Classification of Diseases,* 9th revision; n = number of cumulative incident cancer cases diagnosed between 1984 and 1990; SR = cumulative survival rate; SRR = survival rate ratio; CI = confidence interval; CNS = central nervous system.
[a]A survival rate ratio of 1.00 is the baseline.
[b]Confidence intervals are based on the Mantel-Haenszel chi-squared test.
[c]Invasive.

as it was observed at both 1-year (SRR = 1.06) and 5-year follow-up (SRR = 1.33). In the Detroit metropolitan area, in clear contrast to the Canadian findings, significant associations in the hypothesized direction were observed for 12 of the 15 cancer sites studied 1 year after diagnosis; 10 of 15 (12 of 15 if 90% confidence intervals are used) remained significant at 5-year follow-up (Table 2). The significant 1-year survival differentials, along with their tendency to increase incrementally at 5-year follow-up (e.g., breast SRR = 0.95 1 year and 0.80 5 years after diagnosis; prostate SRR = 0.92 and 0.83, respectively) seem to underscore the importance of both prognostic and treatment-related factors.

Between-Country Comparisons

The two countries did not differ significantly (at the 95% confidence level) on survival for any cancer site in the middle- or high-income groups. This study's central analysis, the comparison of Toronto and Detroit on cancer survival among the poorest third of their respective populations, is displayed in Table 3. Significantly advantageous survival in Toronto was observed for 13 of 15 cancer sites across both periods of follow-up. Rectal cancer and non-Hodgkin's lymphoma were the only nonsignificant exceptions among both women and men, though between-country survival rate comparisons were also nonsignificant for stomach and pancreas cancers among women and brain cancer among men. Each of the 5-year survival comparison point-estimates was in the expected direction (SRRs > 1.00, Toronto advantage), and for the five most common cancers (lung, breast, prostate, colon, and bladder) they may generally be characterized as large differentials, indicative of a 20% (prostate) to twofold (male lung) survival advantage among Canadians who live in relatively low-income areas compared with their US counterparts.

Discussion

We studied the effect of socioeconomic status (SES) on survival from the 15 most common types of cancer among adult women and men in the populations of Toronto, Ontario, and Detroit, Mich. In within-country comparisons, Detroiters' survival from cancer was significantly (95% confidence interval) poorer among people from lower-SES areas in 12 of 15 cancers. No such association was found for 12 of 15 cancer sites among Toronto's population. In the between-country analysis, which compared cases arising from Toronto and Detroit's low-income areas, we found a significant Toronto survival advantage for 13 of 15 cancer sites. Furthermore, in both the within- and between-country analyses, significant survival differentials were observed at 1-year follow-up which increased for most sites at 5-year follow-up, thus underscoring the importance of both prognostic and treatment-related factors.

These findings differ substantially from those of the only other study that has compared Canadian and US cancer survival.[33] Whereas the GAO study found little difference between Canada and the United States in cancer survival, we consistently observed large between-country differences across most cancer sites and periods of follow-up. The GAO study tested only the main effect of country on cancer survival; it did not account for SES in any of its analyses. In this study, we found that SES acts as an effect modifier in such analyses, that is, significant country × SES interactions were observed. Canadian survival advantages were observed only among the ecologically defined poor; the two countries did not differ significantly on survival for any cancer site among middle- or high-income groups.

TABLE 3—Cancer Survival Rate Ratios for Residents of Lowest-Income Areas: Toronto, Ontario, vs Detroit, Mich

	1-Year Survival		5-Year Survival	
Cancer Site	SRR	(95% CI)[a]	SRR	(95% CI)[a]
Women				
Lung–bronchus	1.19	(1.09, 1.29)	1.58	(1.19, 2.10)
Breast	1.06	(1.04, 1.08)	1.30	(1.23, 1.38)
Colon	1.06	(1.01, 1.12)	1.39	(1.20, 1.61)
Bladder	1.19	(1.08, 1.31)	1.46	(1.15, 1.85)
Rectum	1.06	(0.99, 1.13)	1.09	(0.88, 1.35)
Non-Hodgkin's lymphoma	1.07	(0.97, 1.18)	1.27	(0.96, 1.69)
Corpus uterus	1.18	(1.13, 1.23)	1.34	(1.21, 1.49)
Stomach	1.02	(0.87, 1.20)	1.64	(0.93, 2.90)
Oral	1.16	(1.05, 1.28)	1.40	(1.08, 1.81)
Pancreas	1.22	(0.91, 1.63)	1.81	(0.55, 5.93)
Kidney	1.19	(1.07, 1.33)	1.39	(1.04, 1.86)
Ovary	1.12	(1.03, 1.22)	1.38	(1.06, 1.80)
Cervix uterus	1.17	(1.12, 1.23)	1.48	(1.25, 1.76)
Brain–CNS	1.70	(1.27, 2.28)	2.46	(1.12, 5.38)
Men				
Lung–bronchus	1.19	(1.11, 1.27)	1.97	(1.58, 2.46)
Prostate	1.10	(1.08, 1.13)	1.21	(1.11, 1.32)
Colon	1.11	(1.06, 1.16)	1.38	(1.19, 1.60)
Bladder	1.14	(1.09, 1.19)	1.28	(1.11, 1.42)
Rectum	1.04	(0.98, 1.11)	1.13	(0.91, 1.40)
Non-Hodgkin's lymphoma	0.96	(0.87, 1.06)	1.09	(0.83, 1.43)
Stomach	1.28	(1.11, 1.48)	1.73	(1.12, 2.68)
Oral	1.21	(1.12, 1.31)	1.82	(1.45, 2.29)
Pancreas	1.40	(1.03, 1.91)	3.39	(1.32, 8.68)
Kidney	1.16	(1.03, 1.30)	1.54	(1.19, 1.99)
Brain–CNS	1.08	(0.86, 1.35)	1.57	(0.80, 3.09)

Note. A survival rate ratio (SRR) greater than 1.00 indicates a survival advantage for Toronto. CI = confidence interval; CNS = central nervous system.
[a]Confidence intervals are based on the Mantel-Haenszel chi-squared test.

Methodological Issues

Potential ecological fallacy. It is important to note again that the SES variable used in this cumulative survival study was census based, so it is ecological with respect to income measurement. Its analytic goal was not, however, to assign individuals a specific income based on their census tract of residence as a proxy, but rather, to assign them to one of three broad SES classifications: residence in relatively low-, middle-, or high-income areas. The information bias that may intrude because the socioeconomic exposure variable is measured ecologically is clearly far less potent when aggregating cancer cases into socioeconomic tertiles, as in this study, than when such ecological measures are analytically employed as more direct proxies for each individual's SES.[16,43–46] Furthermore, the magnitude of misclassification error that may affect this analysis seems to compare favorably with that routinely encountered in related epidemiologic domains, and it is also likely to be nondifferential.[47,48] An analytic addendum further refutes the notion that this study's ecological measurement of income potentially confounds its findings. When we used income quintiles we found the following: (1) the nonsignificance of Toronto's SES–survival associations was maintained, (2) when we compared the survival experience of Toronto's poorest quintile (median income = $28 000) with Detroit's second poorest (median income = $26 300), the Toronto survival advantage was maintained (e.g., breast SRR = 1.21 and prostate SRR = 1.18, both $Ps < .05$); and (3) such more absolute measures of SES are substantially correlated with this study's relative ones in both the Canadian and US data sets ($r = .93$ and $.91$, respectively, both $Ps < .05$).

The ecological fallacy notwithstanding, we believe it is important simply to know that where people with cancer live, specifically, whether they live in areas where people of low SES tend to be concentrated or in more affluent areas, is highly associated with how long they live in Detroit, but not in Toronto. This study's contextual inferences are thus most relevant to understanding community-level phenomena such as systemic environmental factors that may differ between the countries.[49,50] One such cogent factor, which parsimoniously fits with this study's findings, is the prevailing health care system. It may be assumed that Canada's single-payer system provides more equivalent access to ongoing preventive care and medical consultation when symptoms develop, as well as to the most effective therapies once cancer is diagnosed, than the insurance-driven US system. The present study does not provide the means to directly test this assumption, as the Ontario Cancer Registry does not yet routinely code prognostic and treatment-related variables. A number of variables such as stage of disease at the time of diagnosis are, however, currently available on hard copy for more than 90% of the Ontario cases. Funding is currently being sought to incorporate them into the Registry's electronic database, which would allow a systematic replication of this study that would account for such factors.

Other potential alternative explanations. In addition to the difference in their health care systems, Toronto and Detroit differ in another obvious and, as for the present analysis, potentially confounding way; recent censuses found that many more Blacks live in Detroit's lowest-income-tertile area (68%) than do in Toronto's (5%). Ecological adjustment—selection of a Detroit low-income area with greatly diminished Black representation (20%, the low Black tertile of the low-income tertile)—was necessary because the Ontario Cancer Registry does not code racial group. This imperfect, though substantial, adjustment for between-country racial group differences did not result in any practical alteration of findings. Among those predominantly White people (80% in Detroit and 95% in Toronto) who live in low-income areas, area of residence remains highly associated with how long a person lives after cancer is diagnosed in Detroit, but not in Toronto.

A number of other factors, if they were to differ significantly between Toronto and Detroit low-income census tracts, would confound this study's central analysis: nutrition, physical activity, body mass, smoking, and so on. No previous study has specifically compared the low-income areas of Toronto and Detroit on these factors. However, prevalence studies of general Canadian and US populations suggest that they probably do not explain this study's findings: recent Canadian and US tobacco consumption was found to be equivalent (2.48 kg per adult in 1989), and prevalent differences in other lifestyle-related factors (e.g., weight, alcohol consumption) have been found to be on the order of magnitude of only plus or minus 2%.[51–54] Finally, the possibility that follow-up completion by SES explains this study's findings ought to be addressed. Direct evidence on this score is again lacking, but the fact that ascertainment by death certificate only was not significantly associated with SES among cases arising in Toronto or Detroit makes such confounding improbable.

Conclusions

This large cumulative survival study of persons with the 15 most common cancers in Canada and the United States suggests that it is differences in the two countries' health care systems that explain the pronounced socioeconomic inequality in survival observed in the United States vs Canada's consistently egalitarian distribution. If all Americans had equal access to preventive and therapeutic health care services, between-country differences such as the observed cancer survival advantage among Canadians would likely disappear. A more detailed analysis of histologic, prognostic, and treatment factor differences between individuals with cancer in both countries would go a long way toward strengthening (or refuting) the validity of this inference. □

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